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Standard Environmental Testing Facilities and Practices (900-434), Rev. G

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Revision G: Revised Sections; I D.1, II B.3, Table 3, II E.4. Added Sect. II G & IV.G.1 for compliance with CAN Z69247 & 269248			

I. Introduction

A. Purpose

The purpose of this document is to establish minimum standards for the uniform and controlled exposure of flight quality spacecraft subsystems and instruments to various specified environments. All test agencies performing these environmental tests for spacecraft subsystems shall meet the minimum applicable standards described herein.

B. Scope

This document defines the minimum test standards, equipment, documentation, and general practices necessary to ensure uniform, repeatable testing.

C. Applicability

This document applies to environmental test programs required for flight quality spacecraft subsystems and instruments which are typically specified in Project Documents (See Section I, D.2). The test types and environments covered are shown in Tables 1 and 2.

This document is applicable to testing performed in the JPL Environmental Test Laboratory, other environmental test facilities at JPL and all subcontractor test facilities.

D. References

1. ***JPL Specifications***. The following Jet Propulsion Laboratory Specifications (of the latest issue in effect) form a part of this document to the extent specified herein:

CS503620 “Dynamic Test Fixtures Used in Vibration and Shock, Environmental Tests (Assembly Level), Detailed Specification for”, Rev D., Sept. 16, 1994

ES508915 Fixtures for Use in Thermal Vacuum Tests, Detailed Specification for

D-560 JPL Standard for System Safety

Table 1. Test Types

Test Types*	Abbreviation
Type Approval or Qualification	TA or Qual
Flight Acceptance	FA
Protoflight	PF
Life	LT
Development	DV

* Defined in project documents such as XXX-228 (ref. Section I, D.2)

Table 2. Typical Test Environments

Test Environment	Applicable Test Types
Acoustic	TA, PF, FA, DV
Humidity	TA, PF, DV
Launch Pressure Profile	TA, PF, DV
Shock and Transient Wave Form	TA, PF, FA, DV
Temperature	TA, PF, FA, DV
Thermal Vacuum/Thermal Shock	TA, PF, FA, LT, DV
Thermal Vacuum Bakeout	TA, PF, FA, DV
Vibration	TA, PF, FA, DV

2. ***Project Documents***. The following Jet Propulsion Laboratory project documents are typical references relating to the environmental test program.

XXX-3-240 Environmental Design Requirements

XXX-226 Quality Assurance Requirements for Contractors and Suppliers

XXX-228 System Environmental Program Policy & Requirements

XXX-260 Environmental Test and Analysis Configuration

XXX-265 Spacecraft System Problem/Failure Reporting and Analysis Requirements and Procedures

NOTE: XXX designates the Project.

E. Changes and Revisions

Requests for changes to this document shall be initiated by memorandum to the Manager, Measurement, Test

and Engineering Support, Section 351. Changes which are approved by the Manager of Section 351 shall be incorporated in a revised edition.

II. General Requirements of Test Agency

A. Facility Review Requirements

The Test Agency facilities shall be reviewed to ensure that operating procedures, control and test configurations will provide adequate safeguards for flight hardware and personnel. The facility review shall be performed to determine the Test Agency's readiness to perform a project task and shall be completed prior to testing flight hardware. This review shall be conducted sometime within the twelve- month period preceding the flight hardware test. Additionally, reviews must be repeated whenever significant facility modifications are made or operational procedures are altered.

The Test Agency shall be responsible for demonstrating facility readiness. The safety review shall include the following topics:

1. Standard Operating Procedures
2. Detailed Test Procedures
3. Facility Hardware Configurations
4. Preventive Maintenance Procedures
5. Instrumentation
6. Loading Devices
7. Personnel Assignments and Qualifications
8. Emergency Operating Procedures

The review shall be conducted by a committee that includes the following:

1. Test Agency Manager or his Designee
2. JPL Environmental Test Laboratory Representative (Section 351)
3. JPL Cognizant Hardware Engineer
4. JPL Resident Quality Assurance Representative
5. Flight Project Safety Engineer
6. Occupational Safety Engineer

B. Safety Requirements

The Test Agency shall maintain and enforce written requirements describing safety standards and practices to protect personnel, test articles, and test equipment.

1. ***Personnel Safety***. The Test Agency shall ensure that the areas in which environmental tests are conducted are safe for personnel. This requirement shall include access control, safety devices (barriers, safety glasses, ear protectors, etc.), and the implementation of written personnel safety standards and practices applicable to the particular Test Agency.

2. ***Hazardous Tests***. Test articles and test equipment having hazardous characteristics, such as pyrotechnic devices, propellants, radioactive devices, pneumatic or hydraulic pressures, high voltages, chambers with nitrogen atmospheres, etc., shall be tested with special precautions for safety. Hazardous tests shall not be conducted without JPL approval or the written standards and practices for hazardous tests used by the Test Agency. As a minimum this hazardous test documentation shall be reviewed and approved by the JPL Manager of Section 351 or his representative and the JPL Cognizant Hardware Engineer. For hazardous tests to be performed at JPL, the Safety Review of New Operations (SRNO) form shall also be included with the documentation.

3. ***Handling and Storage***. Requirements and responsibilities for handling and storing test articles are listed in Table 3. All applicable sections of JPL D-560 shall apply to flight hardware handling. All critical lifts shall be performed by trained and certified personnel and witnessed by Quality Assurance.

C. Cleanliness

The area in which environmental testing is to be conducted or test articles are to be handled or stored shall be controlled to the extent necessary to protect the test article from damage or from degradation caused by dust, dirt, corrosives, or any harmful contaminant. Minimum requirements are specified in the following paragraphs of this section. Test article cleanliness requirements more stringent than the following may be imposed by specific JPL project requirements.

1. ***Facility Cleanliness***

(a) Smoking, foodstuffs, and beverages shall be prohibited in all test and flight hardware storage areas.

(b) Unnecessary personnel or equipment shall be prohibited in the test area.

Table 3. Test Article Handling and Storage Requirements and Responsibilities (p. 1 of 2)[a]

Item No.	Operation or Event	Requirement	Responsibility[b]
1.	Delivery of Test Article to Test Area	Test articles shall be packaged or protected and delivered to the Test Agency as specified by the Test Article Cognizant Engineer.	Test Article Cognizant Engineer and quality assurance (QA).
2.	Uncrating	Removal of test articles from transport containers including removal of desiccants, protective covers, or other transport aids shall be performed in controlled handling areas. When applicable, packaging materials shall be removed from the test area.	Test Article Cognizant Engineer and QA.
3.	Special Test Article Handling Devices	Special test article handling devices shall be provided, as required, and shall be proof-tested prior to delivery to the test area.	Test Article Cognizant Engineer and QA.
4.	Connection of Test Fixtures to Environmental Test Equipment	1. Provide labor, tools, and all items required to connect fixture to environmental test equipment. 2. Install control and control monitor transducers at specified locations. 3. Comply with all fixture installation requirements (bolt lengths, materials, torque, etc.	Environmental Test Engineer
5.	Connection of Test Article to Test Fixture	1. Provide labor, tools, bolts, washers, connectors or other items needed to install test article to test fixture.	Test Article Cognizant Engineer and QA.
6.	Hoisting, Lowering or Positioning Test Articles or Test Fixtures with Cranes or Hoists	1. Ensure that load limits of slings, hoists and cables are not exceeded. 2. Ensure that slings, hoists and cables are in valid proof-test status. 3. Ensure that operators are qualified for cranes to be used.	Test Article Cognizant Engineer and QA.
7.	Post-Test	1. Removal of test articles from test fixtures. 2. Packaging and storage or test articles after test. 3. Removal and storage of test fixtures.	Test Article Cognizant Engineer and QA Environmental Test Engineer

[a] Refer to JPL Document D-560.

[b] Applied to JPL organizational structure only. Responsibilities at other test agencies may differ from these and shall appear in detail test procedures.

(c) Shoe cleaners (tacky mats, brushes, or trade standard equivalents) shall be provided at entrances to areas in which test articles are handled or tested, if required by project contamination

personnel.

(d) Test fixtures, test article containers, test equipment, ladders, safety barriers, tools, and other temporarily employed items shall be cleaned by appropriate methods (dust, vacuum, wash, wipe, etc.) before being moved into test areas.

(e) Floors, walls, ceilings, pipe ducts, cable ways, lights, and fixtures shall be cleaned at scheduled intervals.

(f) Inlet air filters shall be inspected, cleaned, and replaced as frequently as may be required to maintain their functional effectiveness.

(g) Drip pans or equivalent devices designed to prevent oil spillage shall be installed as required on cranes and hoists. The devices shall be inspected and cleaned at scheduled intervals.

2. ***Test Equipment Cleanliness***. The Test Agency shall show evidence of effective use of procedures to ensure test equipment cleanliness. These procedures shall include the following:

(a) Materials and methods used to clean humidity chambers, temperature chambers, thermal vacuum chambers, heat exchangers, test fixtures, shrouds, and instrumentation transducers.

(b) Materials and methods used to clean vibration test fixtures, acoustic, shock equipment, acoustic chambers, and all other equipment to which test articles are connected.

3. ***Personnel Cleanliness***

(a) Bare-handed contact with flight test articles shall be prohibited.

(b) If required, special clothing shall be as directed by the cognizant hardware engineer.

4. ***Test Facility Atmosphere Controls***. The Test Agency testing facility shall be housed in a building having a controlled atmosphere. The testing facility shall be a working space that is physically isolated from sources of dirt. The testing facility atmosphere shall conform to the following:

(a) Room temperature shall be controllable at 22°C (72°F) ±3°C (±5°F).

(b) Relative humidity should be maintained between 30 and 60% or as specified in the hardware functional requirements document or by the cognizant hardware engineer.

D. Operating Precautions

Environmental tests shall be terminated whenever a test article failure is detected or whenever a test environment is beyond the limits defined by the detail test procedure. Test abort responsibility shall be as shown in Table 4. The cognizant engineer responsible for the test abort shall also notify Quality Assurance personnel as soon as practical.

Table 4. Test Abort Decisions

Condition or Event	Responsibility
Failure of test article, test article instrumentation, or support equipment.	Test Article Cognizant Engineer
Failure or malfunction of environmental test (or monitoring) equipment during test.*	Environmental Test Engineer
* An environmental test interrupted for these reasons may be continued only when cognizant engineering personnel agree that the test article, test equipment, and personnel are not jeopardized by this decision. (Reference Section II, E.2 for procedure changes after test aborts.)	

E. Test Documentation

Written documents shall be used to specify, conduct, and report all environmental tests. The proper conducting and reporting of environmental tests requires an understanding of the relationships of practices, specifications, procedures, and test reports, as shown in Figure 1. Formal documentation requirements for the control and reporting of all environmental tests are described in the applicable Project Documents. Records associated with this document are maintained in accordance with the Division 35 Records Control Procedure. The following descriptions are for the basic documentation only.

Standard Environmental Testing Facilities and Practices		Environmental Test Specification
This document establishes minimum standards for uniform and repeatable tests. PB Section 351 AB Manager, Section 351		These Documents establish technical requirements for the conduct of FA, TA/QUAL, PF or LT Environmental Tests Req'd 2 weeks prior to tests PB Cog E AP ERE

Detailed Test Procedures
A written, unique test procedure for each test article in each environment for each test type (FA, TA/QUAL, PF or LT) is prepared and used by the Test Agency. This document combines environmental test equipment operating steps with environmental specification test levels and functional operations if appropriate. PB Test Agency AB Cog E

Conduct of FA, TA/QUAL, PF or LT Tests in Specified Environments
Environmental test operations conducted according to detail procedures.

Test Report		Test Results Summary Form
These reports describe the testing which was performed. All facility anomalies, pertinent test interruptions, or deviations from the test procedure shall be documented. PB Test Agency AB Test Agency Supervisor		This form identifies all FA, TA/QUAL, PF or LT tests performed on a test article and summarizes the environmental test results. All anomalies, failures or configuration changes (functional and environmental) are identified. PB COG E AB Quality Assurance

Legend:

AB	=	Approved By
COG E	=	Cognizant Engineer
ERE	=	Environmental Requirements Engineer
PB	=	Prepared By

Figure 1. Relationship of Documents to Environmental Tests

1. ***Environmental Test Specifications***. These documents are prepared by the test article cognizant engineer and identify the set of requirements against which design acceptability must be adequately demonstrated.

2. ***Detailed Test Procedures***. Detailed test procedures shall be prepared and used for conducting all tests on flight type hardware. Their use for DV tests is optional. Standards and requirements for detailed test procedures are specified in the following paragraphs. Outside test agencies shall submit a sample detailed test procedure along with source documents for JPL review and approval by Section 351. The detailed test procedures used by the Test Agency shall conform to this approved sample document in format and content.

(a) **Requirements**. Separate detailed test procedures shall be prepared so that each type of test article has a unique detailed test procedure for each environment and each type of test. Only one detailed test procedure will be required for each environment for different serial numbers for a given type of test (TA, PF, or FA). However, if the test criteria change from one serial number to another, separate detailed test procedures are required.

(b) **Approval**. Detailed test procedure documents for formal tests shall be valid for use when approved by signature and dated by not less than the following four signers:

(1) Cognizant Hardware Engineer.

(2) Environmental Test Engineer.

(3) Test Agency Manager or his representative, (JPL or contractor).

(4) Test - Cognizant Q.A. Representative (JPL or contractor).

Approved detailed test procedures shall constitute certification that the test will be conducted as directed in the detailed test procedure. Q.A. approval shall constitute certification that the test sequence and levels are as specified in the governing environmental test specification and that Q.A. can adequately audit the test.

(c) **Precedence**. Environmental test specifications specify the test requirements that must be reflected in the detailed test procedures. The detailed test procedures shall take precedence over all other documents concerning the conduct of environmental tests. The relationship of the detailed test procedures to other Project Documents is described in Figure 1.

(d) **Content**. Contents of the detailed test procedures shall include, as a minimum, those requirements listed in Table 5.

(e) **Changes**. All waivers or test specification changes must be formally approved by the appropriate project authority, generally the Environmental Requirements Engineer. When these waivers or environmental test specification changes cannot be incorporated into the detailed test procedures before the start of testing operations, the existing detailed test procedure documents shall be changed in accordance with the following:

(1) Test article cognizant engineers, environmental test engineers (JPL and contractor), and Q.A. representatives shall mutually agree upon one marked copy of the detailed test procedures to reflect all changes.

(2) The waiver, if required by the project, shall be identified on the detailed test procedures cover sheet, and the test article, Test Agency, Q.A. representatives and JPL environmental test personnel shall sign and date the cover sheet to signify concurrence with the change entries made.

(3) The revised document shall be retained as a part of the permanent test records.

Table 5. Detailed Test Procedure Content

Requirement Number	Requirement
1.	Detailed test procedure number.
2.	Applicable project. Identify, for example: CASSINI.
3.	Test article name.
4.	Type of test: FA, TA/QUAL, PF, or LT.
5.	Test environment. Identify, for example: vibration.
6.	Names and titles of signers.
7.	Issue date of document.
8.	Applicable documents shall be referenced. Environmental test specification shall be identified.
9.	Identification of the applicable environmental test equipment system.
10.	Unusual security, safety, and cleanliness requirements shall be referenced.
11.	Emergency shutdown procedures shall be stated.
12.	Test report requirements shall be identified.
13.	Test abort decision responsibility shall be stated.
14.	Detailed step-by-step instructions shall include not less than those listed in requirements 15 to 23 below.
15.	Preparation checks of equipment and services.
16.	Instructions to verify calibration status of instruments.
17.	Instructions for alignment of the test equipment system.
18.	Instructions for test fixture installation and removal.
19.	Location and installation of transducers.
20.	Measurements to be taken.
21.	Checkout of the test article protection devices.
22.	Identification of observations or values to be entered on test record data sheets.
23.	System shutdown requirements.
24.	Post-operational checks.
25.	Responsibilities of test participants.

3. ***Test Agency Reports***. A test report shall be prepared for every test, regardless of type, method or result. It is intended that the Test Agency report shall be succinct and prepared in a uniform manner by all test agencies. The test report shall be considered as objective evidence of the activities performed and therefore shall be the "quality record" for ISO 9001 purposes.

(a) **Content**. The content of the test report shall be as specified in Table 6.

(b) **Approval**. The Test Agency report shall be approved by the Environmental Test Laboratory Group Supervisor (or his equivalent).

(c) **Distribution**. The original approved test report shall be submitted to the Cognizant Hardware Engineer after test completion. This report shall be maintained in the Cognizant Engineer's/Project's file system as a "quality record". A copy of the report shall be maintained by the test agency as detailed in Section II.E.5. Additional copies of the test report shall be submitted to the following personnel if so requested.

(1) Quality Assurance Representative

(2) Environmental Requirements Engineer

(d) **Test Data**. Raw data generated during the test shall be retained in reproducible form for a duration specified by the project. The Test Agency shall set up a system for storing and filing environmental test data. The data file number shall be shown on the test report form. The requirements for environmental data collection are specified in paragraph VI-B. Data analyzed from the raw test data will be submitted to the Cognizant Hardware Engineer during and at the conclusion of the test.

4. ***Problem Failure Reports***. The Test Agency shall initiate Problem Failure Reports (PFR) on test facility problems and failures. Requirements for problem failure reporting are contained in appropriate Project Documents, generally PD XXX-265, (XXX denotes the specific project prefix). The PFR shall contain a complete equipment list. A copy of the PFR shall be maintained in the ETL file.

5. ***Test Documentation Retention***. Upon completion of the environmental test, all test documentation shall be collected into a job folder and maintained in a document repository. The documents shall be listed on the Test Agency's Master Control Document List. Test documentation shall be retained and disposed of by outside test agencies as specified by project. The JPL Environmental Test Laboratory shall retain test documentation indefinitely in the following manner: Test documentation will be maintained in a hard copy format for a minimum of two (2) years and then may be transferred to microfilm. The paper and microfilm documentation shall be maintained in the ETL document repository under the control of the ETL document custodian.

F. Access Control

1. The degree of access to a test area shall be the responsibility of the cognizant hardware engineer.

2. The implementation of the access requirements to the test area shall be vested in a member of the Test Agency staff.

G. Auxiliary Power

Although not a requirement of this document, it is desired that the Test Agency has auxiliary electric power and other necessary auxiliary services (gas, water, air, etc.) available for use in continuing a test in the event of failure or malfunction of these essential services.

H. Calibration and Maintenance

The Test Agency shall have a calibration and maintenance program in-place to ensure that the test equipment is capable of safely supporting test operations.

Calibration of measurement and test equipment and transducers shall be in accordance with the requirements of ISO 10012.

Required maintenance activities shall be current and a maintenance record shall be kept with other facility documentation and records.

Table 6. Test Agency Report Requirements

Requirement Number	Minimum Requirements
1.	Test Environment. Identify, for example, vibration, thermal, etc.
2.	Report Number. Identify and correlate with environmental test order.
3.	Applicable project. Identify, for example, CASSINI.
4.	Test agency.
5.	Type of hardware. Identify, for example, FA, TA, DEV or PF.
6.	Identification numbers of detail procedures used.
7.	Name of test article.
8.	Test article serial number.
9.	Applicable test specification or test plan identifier.
10.	Basic environmental equipment.
11.	Identification number of the test fixture.
12.	Environmental equipment operator(s).
13.	Names of: Cognizant Hardware Engineer Cognizant Test Engineer Quality Assurance Representative
14.	Applicable test agency identifier for retrieving raw test data from the storage files.
15.	Identification numbers for all problem failure reports and waivers relative to the test agency environmental facility.
16.	Test summary including a photograph or sketch of the test setup, test profile (if applicable) and remarks relative to any special test conditions or circumstances.
17.	Signature of the test agency group supervisor or his equivalent.

Table 7. Typical Test Data

Environment	Test Parameter	Measurement Mode	Data
Acoustic	Sound Pressure Level, dB	rms or true rms[a]	Record or sound pressure level versus frequency analyzed in 1/3 octave bands and/or constant bandwidth.
Humidity	Relative Humidity	Wet and Dry Bulb Temp°C	Records of wet and dry bulb temperatures versus time.
Shock, impact, transient waveform	Time function geometry (amplitude g versus time) and/or shock spectrum	Response peak g, time history (milli-seconds) and/or shock spectrum	Shock Response Spectrum (SRS) Time History Plot
Temperature	Temperature	°C	Record of temperature versus time.
Thermal, vacuum	Temperature Pressure	°C Torr (n/m^2)	Record of temperature versus time. Record of pressure versus time.
Launch Pressure Profile	Pressure	Torr (n/m^2)	Record of pressure versus time.

Environment		Test Parameter	Measurement Mode	Data
Vibration	Power Amplifiers or Exciter Input Signals	Input Voltage	True rms[a]	Record of amplitude, voltage versus frequency.
		Exciter Current	True rms[a]	Record of amplitude, current versus frequency.
	Random	Acceleration, g	PSD (g2/Hz)	Power Spectral Density (PSD) plot, 5-Hz bandwidth, typical.
		Acceleration, g	rms g (broadband, 20 to 2 kHz)	Record of amplitude versus time.
	Sine	Displacement, in.	Peak to peak	Record of amplitude versus time with frequency markers
		Velocity, in/sec	Average	Record of amplitude versus frequency.
		Acceleration, g	True rms[a]	Record of amplitude versus frequency.

[a] True rms measurements are those measurements performed by instruments which implement the mathematical definition of rms and are not dependent upon the type of waveform for the validity of the measurement.

III. Test Facility Capability Requirements

This section describes the capabilities that the environmental test facilities must have for the performance of environmental tests on flight quality hardware. The criteria listed herein are given for the purpose of establishing minimum test facility capabilities. Detailed environmental test requirements will be specified in the environmental test specifications and detail test procedures.

A. Acoustic

1. ***Chamber Requirements***. The acoustic test chamber shall be a reverberant field type with provisions for installing and protecting the test article during any test. There shall be no less than 10 normal modes in the octave centered at 50 Hz. The spatial variation of the sound pressure level within the chamber shall not exceed 3 dB for any of the 1/3 octave band measurements between 100 Hz and 10 kHz.

2. ***Acoustic Spectrum Control***. The acoustic energy generated within the chamber shall be controlled in 1/3 octave or constant bandwidths between the bands with center frequencies of 50 Hz and 1.0 kHz. The control tolerance in each 1/3 octave band shall be as specified in the environmental test specification. The control tolerance shall not be more than ±l dB for the overall acoustic level in the range 50 Hz to 10 kHz.

3. ***Measurement and Control Requirements***. The sound field shall be measured by means of microphones (four are recommended) placed around the test article. The microphone outputs shall be used to define and control the sound field by means of an averaging system.

The acoustic control and instrumentation system shall be amplitude calibrated with a source accurate to ±0.2 dB, with calibration traceable to the NIST, prior to each test. Overall acoustic level and levels in each 1/3 octave

band or constant bandwidth shall be measured with an rms-detecting meter accurate to ±0.5 dB over the test range. Any constant bandwidth system shall have bandwidths less than the 1/3 octave band at the same center frequency.

B. Humidity

1. ***Test System Requirements***. The humidity test system shall have a temperature range of 2°C (36°F) to 65°C (150°F) and a controlled humidity range of 20 to 95% relative humidity above 10°C (50°F) dry bulb temperature. Test systems capable of maintaining specified temperature levels for time durations of 15 days are required. The test chamber and control system must show a capability for uniform temperature and humidity distribution within the space occupied by the test article. Difference between corner and center point dry bulb temperatures shall not exceed ±3°C.

2. ***Humidity Control Tolerances*** for relative humidity shall be defined in terms of tolerances of wet and dry bulb temperatures. The temperature control systems shall have the capability of holding the control point thermocouple readings to within ±2.0°C (±3.6°F). Strip and circular charts for temperature recordings shall be capable of indicating differences in temperature of 1°C, using a trace less than 0.5°C in width. Indications of thermocouple instrumented wet and dry bulb temperatures shall be accurate to ±1.0°C.

3. ***Test Article-Protection Devices.***

(a) A temperature indicator/controller device which is independent of the humidity chamber control system shall be provided on all humidity chambers. This device shall be designed and operated as specified in Section III-E-6(a). The chamber temperature control system shall be arranged so that the test article temperature returns toward ambient room temperature when control power is interrupted.

(b) A dry laboratory atmosphere or dry nitrogen purge system shall be used for expelling moist air from the test chamber at test completion.

C. Shock and Transient Wave Form

1. ***General***. The mechanical shock system shall consist of a shock machine (ballistic hammer, pendulum, pyro, etc.) or electrodynamic exciter, test article and fixture, monitoring transducers, and signal conditioning equipment.

The transient wave form system shall consist of an electrodynamic exciter and power amplifier with digital control, test article and fixture, monitoring transducers, and signal conditioning equipment.

These systems shall be capable of producing a repeatable shock pulse (or transient wave form) in accordance with the environmental test specification.

2. ***Test Fixture***. The test fixture shall conform to the requirements specified in Section V.

3. ***Shock Monitoring Transducer and Signal Conditioning Equipment***. A transducer shall be used to verify conformance with the requirements of the environmental test specification. This transducer shall have the following minimum characteristics:

(a) Frequency response flat within ±5% from 5 Hz to 30 kHz.

(b) Acceleration amplitude linearity of ±2%.

(c) Cross-axis sensitivity of less than 5%.

The signal conditioning equipment used with the transducer shall have the following minimum characteristics.

(a) Frequency response flat within ±2% from 5 Hz to 20 kHz.

(b) Acceleration amplitude linearity of ±1%.

(c) The slew rate of each piece of conditioning equipment shall be at least 0.6V/microsecond.

D. Temperature

1. ***Test System Requirements***. The temperature test system shall have a temperature range of -54°C (-65°F) to +149°C (+300°F) within the test volume. The test volume shall contain a dry laboratory atmosphere or dry nitrogen gas. Test systems capable of maintaining specified temperature levels for time durations of 15 days are required. The test chamber and control system must show a capability for uniform temperature distribution within the space occupied by the test article. Difference between corner and centerpoint temperatures shall not exceed ±3°C.

2. ***Temperature Control***. The temperature control system shall have the capability of holding the control point thermocouple readings to within ±2.0°C (±3.6°F). Indications of thermocouple instrumented temperatures shall be accurate to ±1.0°C.

3. ***Test Article Protection Devices***.

(a) A temperature indicator/controller device which is independent of the temperature chamber control system shall be provided on all temperature chambers. This device shall be designed and operated as specified in Section III-E6(a). The chamber temperature control system shall be arranged so that the test article temperature returns toward ambient room temperature when control power is interrupted.

(b) The dry laboratory atmosphere or dry nitrogen purge system shall be capable of displacing laboratory atmosphere from the test volume.

E. Thermal Vacuum

1. ***General***.

(a) Test systems for thermal vacuum environments shall have the capability of furnishing controlled excursions of temperature to the test article by means of conduction or radiation.

(b) Test systems for thermal vacuum environments shall be capable of maintaining less than 1 x 10^{-5} torr (1.3 x 10^{-3} n/m^2) pressure for periods up to 15 days with conductive and radiative heat exchangers having temperatures ranging from -185°C (-301°F) to +94°C (+201°F).

(c) The temperature control systems for thermal vacuum environments shall have the

capability of holding the control point thermocouple readings to within ±2.0°C (±3.6°F). Charts for temperature recordings shall be capable of indicating differences in temperature of 1°C, using a trace less than 0.5°C wide. Indications of thermocouple instrumented temperatures shall be accurate to ±1.0°C.

(d) Test systems shall be designed, maintained and operated so that test articles receive no contamination from the test system.

2. ***Conductive Heat Exchanger Tests***

(a) When heat exchangers are used for conductive control of the test article temperature, the heat exchanger control systems shall also have a capability for holding the conductive heat exchanger temperature constant at any level between -185°C (-301°F) and +94°C (+201°F) within a tolerance of ±2.0°C (±3.6°F).

(b) Conductive heat exchangers shall be designed and qualified according to ES508915 (detail specification for thermal vacuum fixtures) with no test article power dissipation. Thermocouples shall be placed on the fixture surfaces using points of attachment that are easily accessible and that do not require modification of the heat exchanger or test article.

(c) Shields shall be provided between test articles and the thermal vacuum system enclosure so that the test article surfaces, not in contact with the conductive heat exchanger, do not radiate heat to the chamber walls. These shields may be a temperature controlled radiant heat exchanger or suitable metal reflectors (metal foil) in contact with the conductive heat exchanger.

3. ***Radiant Shroud Tests***.

(a) Radiant shrouds shall be designed and arranged so that the test article is exposed to surfaces having the capability of close temperature control. The radiant shrouds and the associated temperature control system shall be capable of steady state temperature control at temperature levels between -185°C (-301°F) and +94°C (+201°F) over periods of time up to 15 days.

(b) The temperature of the test article shall be controlled by the set temperature of the shroud. The environmental test operator will set the temperature of the radiant shroud. The radiant shroud temperature control system shall not be arranged to use test article temperature sensors to control radiant shroud temperature.

(c) Radiant shrouds shall be constructed so that the test article may be supported inside the shroud with minimal heat conduction along the support pathways. The test article surfaces not intended for exposure to the shroud must be shielded if specified in the detailed test procedure.

4. ***Thermal Shock (Radiant Heat Transfer) Tests***.

(a) Test equipment shall be capable of exposing the test article to steady state temperatures at specified levels between -185°C (-301°F) and +94°C (+201°F). The test equipment shall be capable of changing the environment from radiant heating to radiant cooling by exposing the test article to a heat sink maintained at -185°C (-301°F) or lower.

(b) The thermal shock test equipment shall be capable of controlling test article temperature

levels as specified in the environmental test specification. This may require that heat sources and heat sinks be alternately energized and de-energized.

5. ***Life Testing***. Thermal vacuum test systems used for life test environments shall have all the capabilities specified for thermal vacuum test systems in this section, and shall be capable of maintaining specified environments for durations of 18 months. Means of maintaining test system operations during facility power interruptions shall be provided. Means of providing uninterrupted service from utility supply systems such as electric power, cooling water, liquid nitrogen, compressed air, the fluids in gaseous nitrogen temperature control systems, and instruments shall be demonstrated by the Test Agency. Detailed test procedures and environmental test specifications shall be used for life tests.

6. ***Test Article Protective Fail-Safe Devices***.

(a) A temperature indicator/controller fail-safe device which is independent of the chamber control system shall be provided on thermal vacuum systems. This device will have its independent temperature sensor installed at the same point or adjacent to the chamber control temperature sensor. The sensor will be arranged to actuate the indicator/controller device which (1) shuts off electrical power to the chamber temperature control system, when the control temperature exceeds the specified stabilization temperature by ±8°C (±15°F); (2) sounds an audible alarm; (3) actuates a device shutting off electrical power to operating support equipment, if appropriate, to specific requirements determined by the test article cognizant engineer. The chamber temperature control system shall be arranged so that the test article temperature returns toward ambient room temperature when control power is interrupted.

(b) The vacuum system shall be provided with an independent vacuum gauge that may be used to remove power from the test article or operating support equipment in the event the test chamber pressure exceeds safe levels. The redundant gauge shall emit an audible alarm whenever the specified pressure tolerances are exceeded.

(c) Leads and wiring for protective device sensors shall be color-marked, numbered, or otherwise visually identifiable to avoid confusion with each other or with other sensor wiring.

F. Vibration

The vibration system consists of the exciter, test article and fixture, control transducer and signal conditioning equipment, servo control equipment, safety devices, and power amplifier. This system shall be capable of producing controlled random or sinusoidal vibration at the test article/fixture interface. The Test Agency shall demonstrate that the system components meet or exceed the requirements specified below.

1. ***Exciter and Power Amplifier***. The exciter and power amplifier shall have the following minimum characteristics:

(a) Capability to produce a broad band random (20 Hz to 2 kHz) or sinusoidal (5 Hz to 2 kHz) vibration input in accordance with the test specification at the test article/fixture interface.

(b) Displacement capability of 1.0 inch peak-to-peak.

2. ***Test Fixture***. The test fixture shall conform to the requirements specified in Section V.

3. ***Control Transducer and Signal Conditioning Equipment***. The control transducer shall have the

following characteristics:

(a) Frequency response flat within ±5% in the range 5 Hz to 3 kHz.

(b) Acceleration amplitude linearity within ±2%, from 5Hz to 3 kHz.

(c) Acceleration cross-axis sensitivity of less than 5%, from 5 Hz to 3 kHz.

The signal conditioning equipment used with the control transducer shall have the following characteristics:

(a) Frequency response flat within ±2% in the range 5 Hz to 10 kHz.

(b) Input/output linearity within ±1% in the range 5 Hz to 10 kHz.

4. ***Servo Control Equipment***. Vibration tests shall be controlled by the equipment specified below:

(a) **Random Vibration Test Control**. Random vibration tests shall be controlled by means of an automatic computer control system. The control tolerances shall be demonstrated by analysis using filters with effective bandwidths of 25Hz minimum, 5Hz typical.

The random noise generation techniques shall produce Gaussian distribution noise. The random vibration noise control capability requirements are given in Table 8. Broad band acceleration control for random vibration shall not be used unless the input signal is low pass filtered at the upper test frequency.

(b) **Sinusoidal Vibration Test Control**. Sinusoidal vibration tests shall be controlled by means of a computer control system. The control capabilities are specified in Table 9. When the levels are specified in rms units, a true rms meter shall be used to assure proper levels.

An analog tracking filter is not acceptable as a component of a control system for sinusoidal vibration test equipment.

5. ***System Safety Devices***. Vibration tests shall be conducted on test systems having, as a minimum, the following equipment:

Table 8. Random Vibration Control Capabilities

Control Parameter	Unit	Frequency Range (Hz)	Control Tolerance	Measurement Accuracies
Random Noise	g^2/Hz	20-2000	±3.0dB in 20- to 25-Hz bandwidths below 1200 Hz, and 50 Hz or narrower bandwidths above 1200 Hz	±0.5 dB
Random Noise	g rms	20-2000	±1dB	2% from 10 Hz to 2 KHz
Broad band random noise levels shall be measured by a true rms meter with a meter-time constant not less than 0.170 sec. The specified shaped spectrum may be controlled by measuring the corresponding broad band random level, if this method is indicated in the detail test procedure, provided that the input signal is filtered at the upper frequency limit of the test specifications.				

Table 9. Sinusoidal Vibration Servo Capabilities

Control Parameter	Unit	Frequency Range (Hz)	Control Tolerance	Measurement Accuracies
Displacement	in	5-2000	±10%	±1% for 0.1 in or greater
Acceleration	g	5-2000	±10%	±2%
Frequency	Hz		±5% of actual frequency but not to exceed 10 Hz	1% ±0.25 Hz of control frequency
Sweep rate (time rate of change of frequency	octave/ minute		±10% of rate less than 1 octave/minute	1 sec out of 15 minutes
			±5% of rate greater than 1 octave/minute	
			"Up" and "Down" sweep rates shall agree to within ±3% over total frequency span	

(a) **Test Article Acceleration Limiter**. An acceleration limiting device, actuated by the control accelerometer signal, shall be provided to limit the instantaneous peak acceleration applied at the test article input point. When actuated, this device shall provide a signal that shuts down the vibration system and does not produce acceleration transients. System shutdown time after actuation by the limiting device shall not exceed .5 second.

(b) **Exciter Protection Devices**. All electrodynamic vibration exciters shall be equipped with two over- travel switches adjusted to limit total displacement to the manufacturer's specified values or approved laboratory limits if exciter is derated. Actuation of either of these switches shall trigger the amplifier protection circuitry specified in the following paragraph and shut down the vibration system.

(c) **Amplifier Protection Circuitry**. All vibration amplifiers shall be equipped with an effective means of dissipating promptly the total energy of the high voltage power supply,

electrically braking the vibration exciter armature, and removing applicable drive voltages.

6. ***Magnetic Fields at The Test Article***. Where required, the Test Agency shall make available to the test article cognizant engineer, prior to testing, plots of magnetic fields at the test article location.

IV. Test Methods and Measurement

This section describes methods for the conduct of environment tests. These procedures are applicable for all formal environmental tests unless otherwise specified in the environmental test specification. Test Agency personnel should be familiar with the following methods before conducting tests:

A. General

1. ***Test Consistency***. The Test Agency shall exercise consistency in the operation of test systems and the assembly of test articles and fixtures into the test system so that the exposure to test environments is made in a uniform and repeatable manner. Special requirements listed in this section shall be included in the methods of test used by the Test Agency.

(a) An environmental test system used to perform a test on specific flight hardware shall be used to perform all subsequent tests on the same test article.

(b) The same fixtures, attachments, and methods of installation of fixtures in test systems used on the initial flight hardware of a specific type shall be used on all subsequent tests on the same or like flight articles.

(c) Control transducers and monitor transducers used during flight acceptance (FA) testing of a test article shall be of the same type, in valid calibration status, and installed at the same locations and connected in a manner identical to that used for type approval (TA) or protoflight (PF) testing of a like test article.

2. ***Test Control***. Usage of terminology shall be guided by the following definitions of terms. Simplification of terms and avoidance of jargon in written matter dealing with environmental tests shall be encouraged.

(a) **Environmental Control**. The magnitude of parameters used to control the environment imposed on a test article is defined in the environmental test specification. The location of the measurement transducer shall be determined after fixture qualification (if applicable) and specified in the detailed test procedure.

(b) **Environmental Test Control Tolerances**. Environmental test control tolerances are the maximum limits of permissible deviation from the specified value of the environmental parameter at the control point. These tolerances will be established for all tests by the environmental test specification. The test systems used to conduct tests must, as a minimum requirement, be able to perform, with a test article installed, within the control tolerances.

(c) **Torque**. This term represents the tightening of a threaded fastener by applying a measured

force at a measured distance from the axis of the thread, as measured by an indicator or scale built into a special wrench used for this purpose. Torque wrenches shall have a valid calibration tag.

3. ***Instrument Calibration***. All measurements necessary to control and measure the test environment and the performance of the test system shall be made with instruments and transducers calibrated in accordance with the requirement of ISO 10012, Quality Assurance Requirements for Measurement Equipment.

B. Acoustic

1. ***General Requirements***. The test article shall be subjected to sound pressure levels as specified in the environmental test specification. The test article volume, in general, is defined as the internal volume of the smallest container which could enclose the test article.

2. ***Test Article Mounting***. The test article shall not be rigidly mounted to any acoustic chamber surface. Small articles may be mounted with a low frequency suspension system of natural frequency less than 20 Hz. Large articles may be installed in the chamber on rubber-tired transport dollies or vibration isolators.

3. ***Acoustic Noise Spectrum Control***. Control of the acoustic environmental field surrounding the test articles shall be accomplished by adjustment of the acoustic spectrum in the chamber prior to the test. This process will be referred to as "chamber equalization." A 1/3 octave band or constant band-width spectrum control system shall be utilized. Chamber equalization procedures are as follows:

(a) When the test article volume is 1%, or less, of the acoustic chamber volume, the empty chamber shall be equalized at the specified test level in conformance with the 1/3 octave band or constant bandwidth levels and tolerances listed in the environmental test specification. The test article then shall be installed in the chamber and tested in accordance with the detail test procedure.

(b) When the volume of the test article is between 1 and 10% of the acoustic chamber volume, a prototype model of the test article may be installed in the chamber and the chamber acoustic spectrum equalized in conformance with the test levels and tolerances specified in the detail test procedure. If no prototype model is available, it will be necessary to equalize with the test article proper. The chamber then shall be equalized at a level at least 6 dB down from the overall level specified in the detailed test procedure. An automatic control system may be used which requires no equalization prior to the test.

4. ***Acoustic Measurement***. Measurements of the acoustic environment and the test article response shall be made as specified in the detail test procedure. Microphones used to measure the acoustic environment shall, in general, be placed approximately 1 foot from the surface of the test article and positioned to minimize errors that may be created by test article sound wave reflections and standing wave patterns within the acoustic chamber. Locations and orientation of the microphones relative to the test article may be determined by pretest evaluation.

C. Humidity

Methods for performing humidity tests shall conform to the environmental test specification and the following requirements for the installation and protection of the test article:

1. The test article shall be installed in the chamber in such a manner, and with suitable shielding, to prevent moisture from impinging directly on the test article.

2. A temperature indicator/controller device independent of the humidity chamber control system shall be used on all humidity tests. The device shall be as specified in Section III-E-6(a). This protective device shall operate if the dry bulb temperature at the control point deviates from the specified level more than ±8°C (±15°F).

3. The test chamber shall be shut down and purged of moist vapor with dry laboratory atmosphere or dry nitrogen gas at the end of test operations to prevent moisture from forming or impinging on the test article or test chamber walls.

D. Shock and Transient Wave Form

1. ***Test Article Mounting***. The test article shall be attached to a test fixture conforming to the requirements of JPL Specification CS503620. The location of the monitoring transducer shall be specified on the test fixture drawing.

2. ***Shock Test Control***. The shock pulse or transient wave form shall be established at the measurement point during pretest trial, as specified in the following paragraphs:

(a) **Shock Test Measurement Tolerances**. The toler-ances for the shock test environment are contained in the environmental test specification.

(b) **Test Implementation**. Requirements for test implementation are as follows:

(1) The shock system shall be calibrated at the test level defined in the detail environmental test procedure prior to each test. This calibration shall be accomplished using a dynamic model or non-flight hardware attached to a qualified test fixture and by applying shock pulses or transient wave forms until the required level and duration are obtained. Subsequent to the calibration, three shock pulses or transient wave forms shall be applied to demonstrate repeatability.

(2) If a low pass filter is used to condition the monitoring transducer signal, the minimum frequency cutoff shall be 10 kHz or as specified in the detailed environmental test procedure.

(3) Accelerometers shall be attached by threaded studs to the shock medium and torqued as specified in the detail test procedure.

(c) **Measurement Location**. Shock pulse or transient wave form measurements shall be made as specified in the detail test procedure. Data collection requirements are delineated in Section VI.

E. Temperature

Methods for performing tests in temperature environment test systems shall conform to the environmental test specification and the following requirements for the installation and protection of the test article.

1. A temperature indicator/controller fail-safe device independent of the temperature chamber

control system shall be used on all tests. This device shall be as specified in Section III-E-6(a). This protective device shall operate if the temperature at the control point deviates from the specified level more than ±8°C (±15°F).

2. Water vapor shall be controlled in the temperature test chamber so that moisture does not condense on the test article or test chamber surfaces. A dry laboratory atmosphere or dry nitrogen gas purge of the test chamber volume before the test article is installed may be used to reduce moisture content. During the test, the chamber shall be purged with dry laboratory atmosphere or dry nitrogen gas to prevent moisture from forming on the test article or the test chamber walls.

3. When the circulating fan discharges directly into the test chamber, shields shall be provided around the test article to prevent impingement of atmosphere on the test article.

F. Thermal Vacuum

Thermal vacuum tests are performed in vacuum chambers, using devices to control the temperature of test articles at gas pressures minimizing convective and gaseous conductive heat transfer.

1. ***Temperature Measurement***. Thermocouples shall be used for the measurement of temperature for the control and monitoring of the environment, test article response when required, and heat exchanger control. Thermocouples may be joined with soft solder, silver solder, or fusion welding methods. Lead wires shall be continuous alloy from the thermocouple to the readout instrument. Reference junctions shall be provided with either constant temperature control or automatic compensation for variations in temperature. Vacuum chamber wall feedthroughs shall be fabricated with continuous alloy lead wires potted or sealed to eliminate dissimilar metal junctions at the feedthrough. Connectors used in lead wire circuits shall be equipped with plugs and sockets of the same alloy used in the leads. Printing thermocouple instruments shall be capable of sufficient data points per minute to indicate that the rate of change of temperature specified for the test is within allowable limits.

A temperature indicator/controller fail-safe device, independent of the thermal vacuum chamber control system, shall be used on all tests. This device shall be as specified in Section III-E-6(a). This protective device shall operate if the temperature at the control point deviates from the specified level more than ±8°C (±15 °F).

2. ***Pressure Measurement***. Vacuum gauges shall be used to measure the pressure environment continuously throughout the test. Gauges shall be suitable for the pressure range being measured and in good working order according to manufacturer's specifications. Vacuum system pressure levels shall be held within tolerances so that the indicated pressures are at least equal to or less than the specified pressure level. Table 10 shows the general accuracy obtainable from readings of meters on gauge instruments. A redundant vacuum gauge shall be installed for each test on flight quality hardware if required by the project. This gauge system shall be capable of sounding an audible alarm when the specification tolerances are exceeded.

3. ***Conductive Heat Transfer***. Conductive heat transfer tests are those in which the test article is assembled to an appropriately designed and qualified heat exchanger plate. The heat exchanger is a fixture designed and qualified according to JPL Specification ES508915. The assembly will be made in the identical manner used during heat exchanger qualification.

Table 10. Accuracy of Vacuum Measuring Devices

Type	Range, Torr	Accuracy of Device, %
Mechanical	Atmosphere to 1 torr	±1 of full scale
Pirani or Thermocouple	1 to 10^{-3}	±3 of full scale
Cold Cathode	10^{-3} to 10^{-4}	±10
Discharge Gage	10^{-4} to 10^{-5}	±25
	10^{-5} to 10^{-5}	±40
Hot Cathode	10^{-3} to 10^{-4}	±10
Ionization Gage	10^{-4} to 10^{-5}	±15
	10^{-5} to 10^{-6}	±30

(a) If the test fixture (heat exchanger) is not Teflon coated, a film 0.001 to 0.002 inch of Teflon material shall be installed between the fixture and the test article. The sheet used shall be identical in thickness and in size and shape to the sheet used during heat exchanger qualification. (This thickness of sheet has been found to improve conduction of heat between metal surfaces, but it is primarily used to protect painted or otherwise finished surfaces which might be degraded by direct contact with a heat exchanger.)

(b) The combined heat exchanger/test article configuration shall be installed in the vacuum chamber so that portions of the test article not shielded by the conductive heat exchanger are shielded from radiant heat exchange with the chamber walls. Foil or other reflective shields shall be placed in contact with the heat exchanger or otherwise held near heat-exchanger temperatures.

(c) The temperature control point for conductive heat exchanger tests shall be established in accordance with the requirements of JPL Specification ES508915.

4. ***Radiant Heat Transfer***. Thermal vacuum tests are controlled by radiant heat transfer from a temperature controlled body to the test article. Care shall be taken to distinguish between the necessary heat exchanger temperature and the response of the test article. Also, care shall be taken when changing temperatures to prevent test article temperature overshoot.

(a) Conductive heat transfer through the mounting or test article support shall be minimized by the use of insulated supports such as Teflon blocks, special string, etc.

(b) The control point temperature sensor shall be identified and located on the test article. This location and the method of attachment shall be described in the detail test procedure.

5. ***Thermal Shock Radiant Heat Transfer***. This type of test is carried out by heating the test article with infrared or other radiant heat source until the desired temperature is achieved. At this time, the heat source is turned off or quickly cooled, and the test article is allowed to radiate to a cold wall or shroud.

(a) Orientation of the test article to the heat source shall be carefully arranged to duplicate the exposure specified.

(b) The temperature of the cold wall shall be monitored throughout the test.

(c) The test shall be implemented to minimize the effects of "afterglow" after the radiant heat source is turned off.

6. ***Pretest Chamber Qualification***. The Test Agency shall provide demonstration tests for each thermal vacuum system using the same test equipment and operating procedures which will be used for flight test articles. The capability of each system to produce and control the test levels and rates of change specified for each heat transfer method shall be demonstrated and recorded. These tests may be combined with fixture qualification tests.

7. ***Life Testing***. Test methods for life testing in thermal vacuum test systems shall reflect the requirement for operating the test systems for periods of 18 months. All test system capabilities must be maintained during that period of time. Requirements for monitoring test systems shall appear in detail test procedures.

8. ***Fixture Qualification Tests***. All conductive heat exchangers used for thermal vacuum environmental tests shall be qualified according to JPL Specification ES508915 in a test system of the same type used in performing environmental tests governed by this document.

9. ***Radiant Heat Exchangers Qualification***. Radiant heat exchangers shall be demonstrated with the thermal vacuum system according to paragraph 6 (Pretest Chamber Qualification) of this section.

G. Vibration

1. ***System Verification.*** Prior to mounting the test article to the fixture, a system verification run must be made for each power amplifier/exciter combination that will be used on a vibration test. Verification will be performed at the full test levels for each dynamic environment specified. Verification will be performed once in the vertical configuration and once in the horizontal configuration. Section 352, Dynamic Environments Group personnel will be notified to obtain their expertise in determining the need for a mass simulator and the design requirements of that simulator for use in the system verification. If Section 352 personnel determine that a mass simulator needs to be built, no further testing shall occur until the simulator is provided.

2. ***Test Article Mounting***. The test article shall be attached to a vibration test fixture qualified according to JPL Specification CS503620.

3. ***Control Transducer Requirements***. The specified vibration test shall be controlled and monitored on the test fixture at the locations determined during fixture qualification according to JPL Specification CS503620. The locations shall be designated on the test fixture drawing.

The minimum transducer requirements shall consist of one control and one monitor accelerometer located adjacent to each other. The monitor transducer shall be used to confirm the control transducer reading. If possible, the monitor transducer shall be conditioned by a charge amplifier, which is scaled to pass signals up to a 200-g peak.

Control transducers shall be attached to the test fixture with a threaded stud. The transducer and stud shall be torqued as specified in the test procedure. The transducer connectors shall be tight, and the cable secured. A continuity check of the transducer signal path shall be made prior to initiating any servo controlled vibration test.

4. ***Exciter Over Travel Protection***. Exciter over travel protection shall be verified at regular maintenance intervals not to exceed twelve (12) months. This protection must be verified after exciter disassembly and repair. Records of maintenance must be kept on file.

The exciter shall be operated with sinsoidal excitation starting at 5Hz. The frequency shall be swept upwards at 1.0 octave/minute while linerally increasing to the exciter displacement until the overtravel switches are activated. The frequency at activation shall be recorded. The displacement at activation must be within 5% of the manufacturers specified limits or approved laboratory limits if exciter is derated. The record of table acceleration shall be reviewed to assure that unacceptable transients are not generated as a result of activation.

5. ***Acceleration Limiting Protection***. The acceleration limiting protection shall be verified before each test. Verification is accomplished by performing the following:

Insert a calibration signal to the accelerometer conditioning amplifier that is equivalent to the desired limit amplitude. Adjust the accelerometer amplifier limiter gain until activation occurs. Repeat as necessary to achieve activation at desired amplitude.

6. ***Random Vibration Tests***. Random vibration tests shall be controlled by means of a computer control system. The wide band (20 Hz to 2 kHz) random noise signal shall be measured by a true rms meter. The shaped spectrum shall be controlled by adjusting the acceleration spectral density (g2/Hz) within the specified frequency band, unless otherwise directed by the detail test procedure.

7. ***Sinusoidal Vibration Tests***. Sinusoidal vibration tests shall be controlled by means of a computer system. Displacement control from 2.5 Hz to 5 Hz may be manual, but the control shall be maintained within ±10% of the specified displacement level. A tracking filter may not be used.

Clipper limiters of any kind shall not be used for sinusoidal acceleration limiting.

V. Test Fixtures

A. General

Test fixtures consist of mechanical devices used to connect test articles to environmental test equipment. Adapters and slider plates used with vibration exciters shall be considered part of the test fixture. Devices used to position shrouds or lamps in thermal-vacuum chambers, unless thermally connected to test articles, shall not be considered part of the test fixture. Test fixture standards and requirements are presented as follows.

B. Design and Qualification

Test fixtures shall be designed and qualified as specified in JPL Specifications ES508915, *Thermal Vacuum Test Fixtures* and CS503620, *Dynamic Test Fixtures*.

Existing test fixtures used on previous JPL Flight Projects shall also be qualified except when the fixture requirements are specifically waived by a JPL Flight Project office. All waivers, relative to fixture qualification, shall have the concurrence of the following:

1. JPL Flight Project Office.

2. Environmental Requirements Engineer assigned to the specific Flight Project.

3. Cognizant Environmental Test Engineer.

NOTE: The cognizant engineer, who is responsible for any specific flight equipment to be tested, may, at his option, request requalification even if a fixture waiver has been granted.

C. Modification

All modifications to existing dynamic test fixtures shall have the approval of the Environmental Requirements Engineer and Environmental Test Engineer prior to use on JPL flight hardware. Modifications which significantly alter the dynamic or thermal characteristics shall be requalified according to the requirements of paragraph B.

D. Storage

Test fixtures that will be required for continued testing, shall be stored at locations affording protection from damaging environments or objects. These fixtures shall carry markings identifying the test article and the test with which they are to be used.

VI. Data Recording

A. Calibration

The Test Agency shall show documentary and visible evidence of possessing, and complying with, a system for calibrating the environmental test equipment inclusive of support instrumentation. The calibration system shall have the capabilities for accuracy, stability, and range suitable for the intended use.

1. ***Equipment Calibration***. The Test Agency calibration program shall meet the requirements of ISO 10012. All related certificates and reports of calibration inclusive of operations performed in compliance with this requirement shall be available for JPL inspection.

2. ***Environmental Test System Calibration***. System calibration procedures shall form a part of the detailed test procedure.

B. Environmental Data Collection

Data shall be collected in a manner that demonstrates test conduct within the accuracies specified for each test.

As a minimum, analyzed data for the control parameters of the test environment shall be included in the Test Agency Report.

The method for collecting the raw data can consist of analog magnetic tape recorders and/or digital storage devices. All raw data shall be identified by:

(a) Test hardware description

(b) Applicable test identifying number

(c) Date or dates on which the data was generated

(d) Description of test performed

(e) Frequency characteristics of recording

(f) Record channel number versus unique measurement description

(g) Calibration levels, where applicable

(h) Scale factors for raw data to engineering units

(i) Voice labeling of dynamic data (acoustics, vibration & shock)

(j) Any other information necessary to facilitate data analysis

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Document Information

Sources and Controlling Documents

Policy: Environmental Test Laboratory Services

Related Documents

Specification: Fixtures for Use in Thermal-Vacuum Tests
Specification: Evaluation & Acceptance of Dynamics Test Fixtures Used in Vibration & Shock Environ Tests

See also:

- Topic: Project Management: Environmental Test
- Topic: Project Management: Environmental Test
- Topic: Project Management: Environmental Test
- Topic: Project Management: Reliability
- Engineering and Technical Documents by Document Code: D- Requirement, Proposal, Guideline, Test Plan

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